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ABSTRACT

The application of a computer simulation of various aspects of the supply and demand for teaching personnel is illustrated with data in the public domain. In addition to several of the variables used in previous simulations of teacher supply and demand, two new features are introduced in this simulation model: a new mechanism for simulating the preservice teacher training component as it supplies new teaching personnel, and new alternatives for considering various categories of certified teachers who may remain in the pool of available teaching personnel for varying lengths of time. A sample computer program and histograms of simulation variable frequency distributions are included. (CHV)

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COMPUTER SIMULATION OF THE SUPPLY AND DEMAND
FOR TEACHERS IN MICHIGAN PUBLIC SCHOOLS

by

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Background Information:
Teacher Supply & Demand

The declining enrollment in public schools has resulted in a large number of new teachers and experienced teachers who were not able to find full-time employment as teachers during the 1970's. For more than a decade the National Center for Education Statistics has published valuable descriptive summaries of the status of education in the United States (8). While the NCES reports have carefully avoided using their data to shape or support some government policy, the Rand Corporation has published an impressive series of monographs in which the authors constructed a theoretical model to explain variations in the supply and demand for teaching personnel in the United States (5).

The Michigan Department of Education has published annual reports during the last three years to describe changes occurring in the number of new teachers trained and the employment of various teaching personnel by Michigan Public School Districts (4).

The Michigan Education Association published its study and interpretation of the supply and demand for new teachers in Michigan (14). Apprehensive over the loss of collective bargaining power when the supply of teachers exceeds the demand, the MEA has lobbied in the Michigan Legislature for a law to place control of the licensing of all teachers in a state board whose membership would be predominantly classroom teachers (2). This has produced a heated dispute between the MEA and most other groups involved in

K-12 education in Michigan, i.e., teacher training institutions, school boards, administrator groups, and the Michigan Federation of Teachers.

In the midst of this dispute, the Michigan Department of Education has attempted to moderate these differences. It has also established a machine processible data base which describes professional personnel and pupils. The records extend back to the 1967-68 school year and contain several million records.

It is particularly important that an impartial source collect these data so that controversies over the training and employment of teaching personnel may be illuminated by reliable and accurate information, rather than consumed in the flames generated by misinformation or mistrust. For example, some persons have used national data when discussing the annual attrition or loss of teachers from the public schools of Michigan. They cite the National Center for Education Statistics which has used 8% as the annual attrition rate for teachers for more than 10 years. However, analysis of the Michigan Professional Personnel Register indicates that the attrition in Michigan was 14% to 15% during the late 1960's. This is almost twice the "historical 8%" level reported by NCES, and represents an error which is non-trivial. In simulations, as in other problem solving efforts, it is essential that we utilize data which are appropriate and sufficiently precise for the situation being studied.

Simulations in Education:

One of the early reports of the use of a simulation model in relation to educational problems was by UNESCO in a 1965 conference

of Ministers of Education who were concerned with planning the educational and economic future of selected nations (19)

The Educational Simulation Model (ESM) evolved through applications in the Phillipines, Spain, Poland, Chile, Kenya, and several Arab states. The UNESCO model reported in 1974 included the following variables: pupil enrollment, population projections, repetition, promotion rates, drop-out rates, migration, teacher supply and demand, teacher salary, salaries of other personnel, administrative costs, and capital expenses. Mathematical expressions defined these variables and related them to the ESM projections of enrollment, teachers needed, and expenses incurred.

The UNESCO report also described a data processing model written in FORTRAN for the ICL 1902A computer, but it did not include examples of output from the computer runs of the simulation program.

Boardman described an impressive simulation system in 1971 which was part of the National Educational Finance Project (3). The simulation was written in PL/1 for a time-shared IBM 360/65 computer system. It was intended to support executives and policy makers at the state level in reaching decisions about financing public K-12 school districts. A hypothetical state was defined with real data from 32 school districts which represented a wide range of socio-economic, population, wealth, and expenditure categories. Input variables were coded so that variables could be assigned specific values and the consequences of these decisions were presented in tables and graphs for all 32 districts.

The results of Project SIMU School have provided valuable examples of computer simulation as applied to problems of supporting local school districts when enrollment and funding resources are changing. In Texas, the Dallas Independent School District reported three separate simulations dealing with projecting a district's revenues and expenditures, pupil enrollment and instructional facilities, and faculty employment.

The financial projection program of the Dallas component of Project SIMU School was tailored to the Texas budget format and their Minimum Foundation Program (1). It permits a user in Texas to describe the local district in terms of pupil enrollment, faculty experience in relation to a State salary schedule, administrators, special services, state or local revenues, Minimum Foundation Program projections and similar input variables. Output from the simulation provides tables listing expected revenues, expenditures, and other entries in the budget format required by Texas Department of Education. Categories of input are carefully defined for card input to the simulation.

The Dallas group also developed a simulation model which used cohort survival techniques and the system responds interactively to a user in securing enrollment projections and expected needs for instructional facilities. (9)

In a third paper, the Dallas group described a program for simulating future faculty requirements using transition probabilities of faculty members remaining or departing, achieving advanced degrees, and changing teaching assignments. The

simulation was written in FORTRAN IV for a Burroughs computer (6).

In another report of Project SIMU School, Linebarger described a computer simulation of enrollment based upon land-use and other variables (10). Denham's doctoral study was an early effort at using monte carlo computer simulation to make enrollment predictions (7).

The intent of the simulation model described in this paper was to provide an additional tool which can be used in Michigan and elsewhere to enable educational planners to consider interrelated variables in their study of the supply and demand for teaching personnel. We share the viewpoint expressed in the UNESCO report that the simulation model is simply a tool for considering alternative paths in the development of a statewide educational system, e.g.,

...The purpose of the simulation model is merely to identify the consequences of changes (based on various assumptions or estimates) in defined conditions affecting the behavior of the system. (19)

Description of Model

The simulation model was developed for the College of Education, Wayne State University. However, the model and the computer program are sufficiently general so that they may be applied to other teacher education programs which are substantially influenced by the variables used in this system. That is, the names can be changed and new data may be entered to replace the data used in

this simulation for Wayne State. Essentially, it's up to the user to decide whether or not the model's components are appropriate for the situation which he/she wishes to explore.

Figure 1 illustrates the major components in the simulation model: (a) admission to teacher education program, (b) career decisions after graduation, (c) employment in public or private schools, (d) permanent or temporary leave from teaching activities.

The simulation starts with event #3 when the students are officially admitted to the College of Education. The teacher education program is assumed to be a two-year program (event #4). However, the simulation provides a mechanism for enabling students to complete the program in a variable number of terms. Some proportion of the students who are admitted to the college will drop out of the program indefinitely or at least for the duration of the simulation (event #10).

Those who do graduate may enter the job market to seek immediate employment in public schools (event #7) or non-public schools (event #9); while other graduates may seek non-teaching employment (event #6) or enter graduate school (event #8). Some proportion of those seeking employment will find it in public schools (event #11) or in private schools (event #17); and graduates of an earlier time (event #18) may return to find employment in the public schools. Moreover, graduates from other teacher training institutions (event #12) will also be competing for jobs in the public schools.

Teacher attrition (event #13) is considered to be either permanent retirement from teaching (event #14) or temporary leave

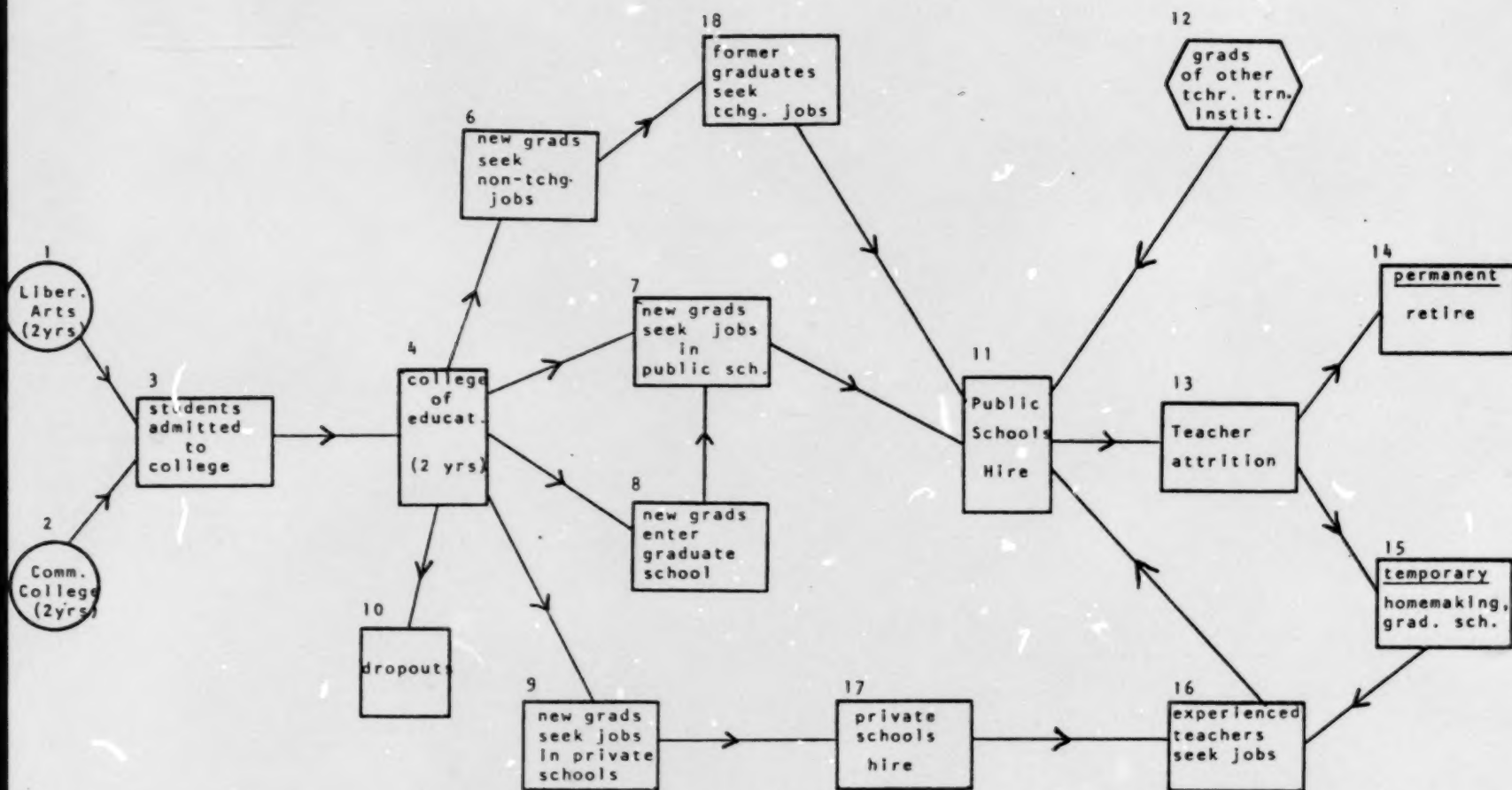


Figure 1 - FLOWCHART ILLUSTRATES PATTERN OF STUDENTS ENTERING TEACHER TRAINING AND SEEKING EMPLOYMENT AS USED IN SIMULATION MODEL

(event #15). In the latter case, the experienced teachers will seek to be reemployed (event #16) and experienced teachers from private schools will also seek employment in public schools.

For each of the preceding events, the simulation program allows the user to specify the number of persons and number of terms to elapse before they enter or leave a particular event. If there are not enough openings for employment of beginning teachers, then the program forms a queue which follows the constraints specified by the user as long as the constraints do not violate the limitations of another variable. For example, the simulation could not order the employment of 500 beginning teachers if there were only 200 beginning teachers available. This would require a program modification or switch which may be inserted at a later time. For example, the present simulation model does contain a switching mechanism which permits the user to decide whether or not he/she will use deficit spending, then the simulation program will follow this constraint regardless of the cost. The results are subsequently illustrated in a graph showing the annual accumulation of the deficit.

Figure 2 illustrates the major sources of revenue which are monitored by the simulation as well as the major categories of expenditure. In Michigan, the local aid per pupil is defined by the product of the operating millage rate in the local district (#1) and the State equalized value of property within the school district (#2).

State aid per pupil (#4) is determined by the Michigan Legislature each year. After considerable debate, the State aid for each district is set at a value which conforms to a complicated formula.

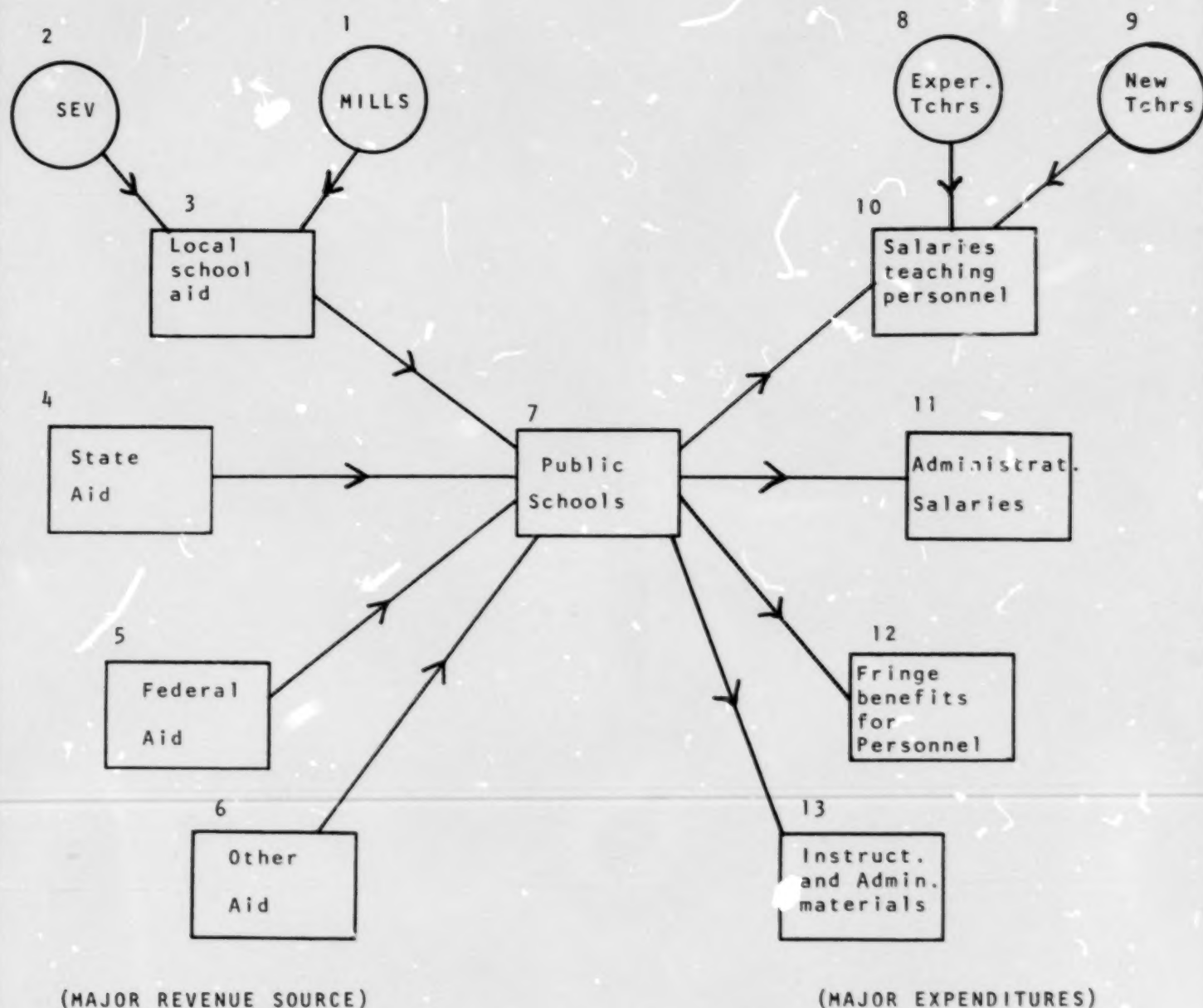


Figure 2 - FLOWCHART ILLUSTRATES MAJOR SOURCES OF REVENUE AND MAJOR EXPENDITURES IN SIMULATION MODEL

During the past few years, State aid has been intended to provide additional money for poor districts and less money for the wealthy districts, so that the quality of education of any child will not depend upon the child living in a wealthy district.

Federal aid per pupil (#5) may be in the form of direct grants to qualified school districts or indirect awards which are transmitted through the Michigan Department of Education. Other school revenues (#6) may be received from private gifts or contributions from the intermediate school districts.

Major categories of expenditure are shown in items #8 through #13. Expenditures for teachers' salaries (#10) are determined by salaries for experienced teachers (#8) and for beginning teachers (#9). The remaining expenses for operating the schools are attributable to administrators' salaries (#11), fringe benefits (#12) and the cost of instructional or administrative materials (#13). All categories in Figure 2 may be modified according to the wishes of the user of the simulation program.

Table 1 identifies the major variables utilized in the simulation model. For teacher education, there are four variables which relate to the proportion of students in the undergraduate or graduate programs and the number of terms that they remain in a program. After each variable, the expression in parentheses indicates the type of data expected by the simulation program.

There are ten variables used in the employment phase of the simulation. They relate to career choices of the graduates of the College, to the job market as reflected in competition for

TABLE 1 - ELEMENTS IN TEACHER EDUCATION AND EMPLOYMENT MODEL
WHICH MAY BE CHANGED IN USE OF SIMULATION PROGRAM

TEACHER EDUCATION VARIABLES:

1. Admission to college/department of education (number/terms)
2. Dropouts of teacher education program (percent)
3. Time to graduate (percent/terms)
4. Seek graduate education (percent/terms)

EMPLOYMENT VARIABLES:

1. New graduates seek public school jobs (number, % success)
2. New graduates to non-teaching jobs (% enter/return, terms)
3. New graduates seek private school jobs (% enter/leave, terms)
4. New graduates to graduate school (% enter, terms)
5. Non-teaching graduates return to teach (percent, terms)
6. Public school teachers (number at start)
7. Teacher attrition permanent or temporary, (percent, terms)
8. Wayne's share of teacher market (number at start, % change)
9. Public school enrollment (number)
10. Pupil-teacher ratio (number)

REVENUE AND EXPENDITURE VARIABLES:

1. Millage rate for local district (mills)
2. State equalized value per pupil (dollars)
3. State aid per pupil (dollars)
4. Federal aid per pupil (dollars)
5. Other aid per pupil (dollars)
6. Average salary of beginning teachers (dollars)
7. Average salary of experienced teachers (dollars)
8. Option to use deficit financing (yes/no)
9. Percent of total budget for administrative or non-instructional salaries (percent)
10. Percent of salaries for fringe benefits (percent)
11. Percent of total budget for other expenses (percent)

employment, to pupil enrollment changes, and to the pupil-teacher ratio in a school district.

The simulation includes eleven variables which influence the revenues and expenditures of a school district. The revenues are dependent primarily upon local, state, and federal aid. Expenditures are primarily for salaries and instructional/administrative materials.

Table 2 shows a line file of data used as input in a typical run of the simulation program as it is applied to the Detroit Public Schools. In the first column is the line number and the second column lists the corresponding data element. The third column provides a brief explanation for several data elements.

For example, line 2 indicates that the user wants the simulation to run for 15 years, and line 3 states that it will start with the year 1968. The warm-up period in line 4 is to last 5 years and enables the system to build up a set of students entering the College and graduating. Therefore, the employment portion of the simulation will not start until the year 1972 and all simulation components will then interact for the remaining 10 years of the 15 year simulation.

The data in lines 6 through 6.4 are control statements indicating a preference for interactive or batch processing, the number of data elements to be entered, and whether or not the user wishes to draw upon the program's extrapolation routines or prefers to specify a uniform rate of change. Line 6.6 indicates the actual number of data elements which the user can provide for

millage. Line 7 contains the three millage rates for the years 1972, 1973, and 1974. Line 9 shows a 4% rate of change requested by the user; and lines 10 and 11 show the minimum and maximum rates which the user expects may be achieved by this 4% rate of change. Other data elements in Table 2 follow a similar pattern as noted in the explanatory notes.

The simulation program also includes an interactive mode of entering data. Table 3 illustrates several lines of interaction between a typical user whose remarks are underscored in Table 3, while the computer program issues prompts in capital letters.

Sources of Data:

It is important to recognize that the value of any simulation is determined by at least two factors. First, it is essential that the simulation model includes the major variables in the situation being modeled. In other words, does the model correspond with reality. Secondly, the precision of the model's fit with reality is dependent upon the quality of the data which are collected to measure the frequency and intensity of the variables included in the simulation.

The Michigan Department of Education has been very helpful in supplying data as requested by the researchers. We have drawn upon the computer tape files of the Michigan Professional Personnel Register (1967-1977) to gather evidence of teacher employment, attrition, salary levels, and similar information about teaching personnel (15).

TABLE 2 - TYPICAL INPUT IN BATCH RUN OF SIMULATION MODEL

Line No.	Data Elements	Explanation
2	15	Select duration of Simulation (years)
3	68	Year Simulation starts (year)
4	5	Warm up before Simulation starts (years)
5	4	
6	'1'B	
6.2	'0'B	
6.4	'0'B	Extrapolation not used
6.6	3	3 millage data elements (mills)
7	22. 24. 27.	
8	'1'B	
9	4.	Millage change rate (%)
10	20.	Minimum/maximum (mills)
11	30.	
12	'1'B	
13	'1'B	
14	'0'B	
15	'0'B	
16	4	
17	20521. 21650.	State Equalized Evaluation/pupil (\$)
18	22088.	
19	22838.	
20	'1'B	
21	6.	SEV change rate (1%)
22	20000.	Minimum/Maximum (\$)
23	35000.	
24	'1'B	
25	'1'B	
25.2	'0'B	
25.4	'0'B	
25.6	4	State aid/pupil (\$)
26	439. 514. 603. 646.	
27	'1'B	
28	4.	State aid, change rate (%)
29	400.	Minimum/Maximum (\$)
30	1200.	
31	'1'B	
32	'1'B	
32.2	'0'B	
32.4	'0'B	
32.6	4	Federal aid/pupil (\$)
33	127 129 160 163	
34	'1'B	
35	5.	Federal aid, change rate (%)
36	100.	Minimum/Maximum (\$)
37	1000.	
38	'1'B	
39	'1'B	
40	'1'B	
41	.36 .19 .35 .29 .30 .50 .50 .50 .50 .50 .50	Other aid/pupil (\$)
42	0	

TABLE 2 - TYPICAL INPUT IN BATCH RUN OF SIMULATION MODEL
(cont.)

44	1 0	
45	'0'B	
46	'0'B	
47	4	
48	281594	
49	267742	Pupil enrollment (number 1 year)
50	260905	
51	253982	
52	'0'B	
53	-2.	
54	-1.75	
55	-1.75	
56	-1.5	Enrollment change rate (%)
57	-1.	
58	-.5	
59	0.0	
60	200000	Minimum/Maximum (\$)
61	300000	
62	'1'B	
63	'1'B	
64	1	Deficit budget (yes/no)
65	70.	Experienced teachers to be hired (1%)
66	'0'B	
67	26.	Pupil-teacher ratio (number)
68	'1'B	
69	0.	Pupil-teacher ratio change rate (%)
70	26.	
71	26.	Minimum/Maximum (number)
72	'1'B	
73	'0'B	
74	9265.	Average salary beginning teachers (\$)
75	'1'B	
76	6.	Average salary change rate (%)
77	9000.	Minimum/Maximum (\$)
78	13000.	
79	'1'B	
80	'0'B	
81	15000.	Average salary experienced teachers (\$)
82	'1'B	
83	6.	Average salary change rate (%)
84	13000.	Minimum/Maximum (\$)
85	22000.	
86	'1'B	
87	27.	Administration & Non-teaching expenses (%)
88	0.	
89	25.	
90	'1'B	Fringe benefits expenses (%)
91	'0'B	Other expenses (%)
92	'1'B	
93	12	
94	641 641 641 641	Admission to College of Education (number)
95	627 627 627 627	
96	552 552 552 551	
97	100	Minimum/Maximum (number)
98	1000	
99	'0'B	
100	50.	Dropouts (%)
101	'1'B	
102	0.	Dropout change rate (%)
103	50.	
104	50.	Minimum/Maximum (number)
105	'1'B	
106	4	
107	50. 8	Terms for Teacher Education Program (%/term)
108	25. 12	

110	10. 20	TABLE 2 - TYPICAL INPUT IN BATCH RUN OF SIMULATION MODEL (cont
111	125	
112	3.	Grads seeking graduate school (%)
113	4	
114	50. 2	
115	20. 3	Terms in graduate school (%/terms)
116	20. 4	
117	10. 5	
118	15.	Grads to private schools (%)
119	0	
120	35.	Grads from private schools to public schools (%)
121	3	
122	35. 4	
123	45. 8	Time to seek public school employment (%/terms)
124	20. 12	
125	30.	Grads to non-teaching jobs (%)
126	500	
127	30.	Non-teaching grads return to teach (%)
128	8	
129	30. 4	
130	20. 8	
131	10. 12	
132	10. 16	
133	10. 20	Time lapse before non-teaching grads return (%/terms)
134	10. 24	
135	5. 28	
136	5. 32	
137	0	Beginning teachers seeking jobs (number)
138	90.	Beginning teachers unsuccessful in finding job (%)
139	0.	Experienced WSU teachers seek jobs (number)
140	60. 40.	Hiring experienced vs. beginning teachers (%,%)
141	0.	Number non-teaching grads seek to teach (number)
142	8.	Teacher attrition (%)
143	30.	Experienced teachers seek teaching job (%)
144	4	
145	60. 4	
146	30. 8	Time lapse before experienced teachers return (%/term
147	5. 12	
148	5. 16	
149	5132	Employed WSU teachers (number)
150	10109	Total teachers in school district (number)
151	6	Reports
152	1 2 3 4 5 34	

TABLE 3 - INTERACTIVE USE OF SIMULATION PROGRAM

run sim.col**p11lib

#EXECUTION BEGINS
WILL YOU ENTER THE DATA ON THIS TERMINAL ?
PLEASE ANSWER AS 'YES' OR 'NO'

yes

DO YOU WANT THE OUTPUT PRINTED ON THE TERMINAL ?
PLEASE ANSWER AS 'YES' OR 'NO'

no

PLEASE PROVIDE THE OUTPUT FILE NAME

-x

DO YOU WANT TRACE OF THIS PROGRAM ?
PLEASE ANSWER AS 'YES' OR 'NO'

no

PLEASE SUPPLY THE FOLLOWING DATA
AND DO SO BY TYPING THE VALUE AFTER EACH QUESTION

THE TIME IN YEARS FOR THE DURATION OF THIS SIMULATION RUN ?

15

WHAT IS THE STARTING YEAR FOR THIS SIMULATION RUN ?
PLEASE PROVIDE ONLY TWO DIGITS, E.G. 69

68

PLEASE PROVIDE THE TIME PERIOD IN NUMBER OF YEARS FOR THE WARM UP TIME OF
THIS SIMULATION AHEAD OF THE ACTUAL SIMULATION PERIOD

5

20

THE NUMBER OF ACADEMIC TERMS (QUARTERS OR SEMESTERS) PER EACH CALENDER YEAR ?

THE SCHOOL MILLAGE
DO YOU HAVE MORE THAN 1 VALUE ? - 18 -
PLEASE ANSWER AS 'YES' OR 'NO'

yes

DO YOU HAVE DATA FOR ALL YEARS?
OR FOR ENTIRE DURATION OF SIMULATION
PLEASE ANSWER AS 'YES' OR 'NO'

no

DO YOU NEED EXTRAPOLATION ?
PLEASE ANSWER AS 'YES' OR 'NO'

no

HOW MANY VALUES ARE TO BE READ IN ?

3

PLEASE SUPPLY 3 VALUES

22. 24. 27.

DO YOU NEED FIXED RATE OF CHANGE ?
PLEASE ANSWER AS 'YES' OR 'NO'

yes

PLEASE PROVIDE THE FIXED RATE OF CHANGE (IN %)

4.

WHAT IS THE LOWER LIMIT ON THE VALUE OF THIS DATA ?

20.

AND WHAT IS UPPER LIMIT FOR THE VALUE ?

30.

WILL THIS CHANGE BE CUMULATIVE
PLEASE ANSWER AS 'YES' OR 'NO'

For the fiscal data of a school district we have used the Michigan Department of Education Bulletins 1011, 1012, and 1013 for the years 1970 through 1975 (11, 12, 13). These are official records of revenues and expenditures of each school district in Michigan.

Records of admissions and quarterly registration (1971-1976) for the College of Education were used to estimate the numbers of students admitted, the time required to complete the teacher education program, and the number of graduates each year.

In general, the writers believe that their historical estimates of these parameters are reasonably precise. The quality of the estimates of future parameters as produced by the simulation program is open to dispute.

With respect to a model of the real world of teacher training and employment, we believe that our model is fairly comprehensive. However, there are some blemishes in our model and we have identified them in the following section.

Limitations of the Study:

The following remarks call attention to some of the limitations in the simulation model which we have developed; and undoubtedly, the reader will identify others. One major concern to the writers is that the model does not identify the role of the substitute teacher and indicate the influence of the substitute upon the supply and demand for full-time teaching personnel. We believe that hundreds of graduates choose to be substitute teachers for various reasons and remain in this role for varying periods of

time. Some personnel directors have said that they select most of their new full-time teachers from the pool of substitute teachers. However, we have not been able to gather adequate data on the number, background, frequency of employment and other variables relating to employment of substitute teachers in the public schools of Michigan.

A second limitation is introduced by lumping together all persons trained at other institutions who are competing for positions in the public schools. A more definitive model would distinguish between graduates of Michigan colleges and graduates of institutions outside of Michigan; and a further refinement would enable the user to specify several separate institutions competing for employment in a specific school region.

A third limitation is that this model does not include a provision for using pupil achievement data to influence expenditure of funds, changes in pupil-teacher ratios, or other variables in the simulation. We believe that future planning for staffing and funding the schools should go beyond "pupil headcount" and be influenced by "what's in the head."

Finally, several variables in the simulation are very gross indicators. For example, the great variety of pupil-teacher ratios in Detroit Public Schools is not evident when one simply divides total enrollment by total teaching positions to produce a District pupil-teacher ratio. These rough indicators reduce the precision of the calculations and thereby diminish the quality of the simulation.

Computer Program:

The simulation was written in PL/1, after preliminary attempts with GPSS and Simscript indicated that these simulation languages were not suitable for our approach to this problem area. The PL/1 pre-processor enabled us to define special commands and incorporate them into macros in the system. With this facility we were able to define modules within the simulation which were easier to change and debug.

The simulation may be operated interactively in response to prompting statements from the program; or the user may build a data file of about 150 lines for batch processing. The simulation program runs on Wayne's IBM 360/model 67 computer, which executes a simulation in batch mode in about 4 minutes. Interactive use requires more time to enter the data, but the prompting statements should improve the user's understanding of the structure of the simulation.

Output of a simulation run is a set of 42 histograms illustrating various assumptions or consequences of the simulation input. Other tables and a trace of the program may be selected. The program is not readily portable to another computer installation. It should be accessed through telephone lines and conventional time-sharing procedures. Cost of a typical run, excluding line charges, is about \$3.00 for executing the program and \$2.00 for the paper on which the histograms are printed.

Extrapolation routines may be called by a user. At least 3 data elements must be provided for extrapolation, and they are

used to define a parabola, a straight line, and a hyperbola of "n" degrees. The "best fit" polynomial is used to extrapolate data points for the variable under consideration.

Discussion of Input/Output of Simulation

As indicated previously, we have relied upon official records where they were available; and we have analyzed existing data bases of the Michigan Department of Education to extract those items which were not readily available in the official records, e.g., teacher attrition and return to teaching. The preliminary steps in using the simulation involve a period of "fine tuning" during which the user altered the input of data for each variable in terms of the historical record. If you had 5 data elements, then 3 data could be entered with an assumed rate of change and use the remaining 2 data points to check the accuracy of the estimated rate of change. Subsequently, the user must judge the extent to which extrapolation with empirical equations, fixed rate of change, or subjective estimates of future data points provided the most precise image of a given variable over the time period of the simulation.

Input specified in Table 2 reveals some of the implicit assumptions made for this particular run of the program. With respect to revenue available to the schools, we've made the following assumptions as reflected in the hypothetical data presented in Table 2:

<u>Lines</u>	<u>Assumption</u>
48-59	Enrollment declines from -2% to 0
17-23	SEV/pupil increases 4% annually
7-11	Millage increases 4% annually
26-30	State aid/pupil increases 4% annually
33-37	Federal aid/pupil increases 5% annually
41	Other aid/pupil is known for duration of simulation

The funds resulting from the preceding assumptions will generate a certain number of dollars each year for the Detroit Public Schools to use in paying salaries and other operating expenses. Histogram 1 shows the projected revenues for the Detroit Public Schools from 1973 through 1983 under the preceding constraints. After 1974, the annual increase in total revenues is about 4% until 1978 when the annual increase drops to 3%. Thereafter, there is deterioration in the funds available to operate the schools.

Histogram 2 illustrates the District's increasing state equalized value per pupil and Histograms 4, 17, and 19 show increases of 4% and 5% in state and federal aid while local aid per pupil varied from 6% to 10%. The cumulative effect of a declining enrollment and a slowly increasing total assessed valuation produced the deteriorating conditions indicated in Histogram 1.

Input in Table 2 shows the following assumptions about the expenditures in this simulation:

<u>Lines</u>	<u>Assumptions</u>
74-78	Beginning teachers' salaries increase at 6%
81-85	Experienced teachers' salaries increase at 6%
67-71	Pupil-teacher ratio is stable at 26:1
142	Teacher attrition is 8%
87	Administration/non-teaching salaries are 27% of total expenses
88	Fringe benefits set at zero
89	Non-salary expenses are 25% of total expenses

Histograms 7 and 8 show the increase in average salaries of beginning and experienced teachers, while Histogram 9 shows the

decline in the total number of teachers required to maintain a pupil-teacher ratio of 26:1 with an annual teacher attrition level of 8%.

Histogram 18 shows the cumulative effect of these assumptions with a graph of the annual expenditures for the district. A comparison of revenues and expenses produced the net effect illustrated in Histogram 15, which shows a deficit starting in 1973-74 and ending in 1977-78.

The simulation program permits a user to modify 1 or more of the variables in order to secure a "fit" which is judged to be closer to "reality". For example, one could argue that Michigan law requires the 9,000 special education teachers to have classes with no more than 15 pupils and many classes must be smaller. Therefore, a user might wish to repeat the simulation with smaller pupil-teacher ratios or introduce new data for separate analyses of special education and "regular education" programs.

Availability of new teachers or experienced teachers is specified by the following assumptions in Table 2:

<u>Lines</u>	<u>Assumption</u>
93-98	New admissions decline an average of 7%
100	Dropout of newly admitted students is 50%
107-110	Students completing program in 2 years is 50%
125	New graduates seeking non-teaching jobs is 30%
127	Graduates in non-teaching areas who return to teach is 30%
138	Unemployed new grads active for 1 year job hunting 90%
142	Annual teacher attrition is 8%
143-148	Experienced teacher return is 30%
120	Graduates moving from private to public schools is 1%

Histogram 24 shows that by 1982-83 new admissions have declined to less than 25% of the number of newly admitted students in 1973-74. Graduates will have declined by 66% (Histogram 30) and new teachers seeking employment in 1982-83 will be less than 200 (Histogram 31).

With an annual attrition rate of 8% and the return of experienced teachers set at 30, Histogram 34 shows a pool of more than 2,000 experienced teachers from all institutions waiting to return to teaching during any single year of the 10 year period covered in the simulation.

Concluding Remarks:

In this paper we have described a computer system which simulates various aspects of the supply and demand for teaching personnel; and we have illustrated its application with data in the public domain. We believe that this system can be very helpful to educational leaders as they consider alternatives in their plans to achieve goals and to allocate resources to public schools as well as to colleges and universities.

The simulation model reported in this paper includes several of the variables used in previous educational simulations of teacher supply and demand. However, we have introduced a new mechanism for simulating the pre-service teacher training component as it supplies new teaching personnel.

We have also introduced new alternatives for considering various categories of certified teaching personnel who may remain in the pool of available teaching personnel for varying lengths of time.

Finally, the simulation is interactive and relatively easy to use. We are willing to make the program available to others who wish to use the system through the conventional time-sharing systems, and we will assist them to the extent that we have available time and energy.

HISTOGRAM 1

ANNUAL FREQUENCY DISTRIBUTION OF THE TOTAL SCHOOL REVENUE FROM LOCAL TAXES, FEDERAL, STATE AND OTHER AIDS (IN MILLIONS OF DOLLARS)

FREQUENCY	311	355	368	384	403	416	430	444	451	462
EACH * EQUALS	10									
460									*	*
450								*	*	*
440							*	*	*	*
430							*	*	*	*
420						*	*	*	*	*
410					*	*	*	*	*	*
400					*	*	*	*	*	*
390					*	*	*	*	*	*
380				*	*	*	*	*	*	*
370				*	*	*	*	*	*	*
360			*	*	*	*	*	*	*	*
350		*	*	*	*	*	*	*	*	*
340		*	*	*	*	*	*	*	*	*
330		*	*	*	*	*	*	*	*	*
320		*	*	*	*	*	*	*	*	*
310	*	*	*	*	*	*	*	*	*	*
300	*	*	*	*	*	*	*	*	*	*
290	*	*	*	*	*	*	*	*	*	*
280	*	*	*	*	*	*	*	*	*	*
270	*	*	*	*	*	*	*	*	*	*
260	*	*	*	*	*	*	*	*	*	*
250	*	*	*	*	*	*	*	*	*	*
240	*	*	*	*	*	*	*	*	*	*
230	*	*	*	*	*	*	*	*	*	*
220	*	*	*	*	*	*	*	*	*	*
210	*	*	*	*	*	*	*	*	*	*
200	*	*	*	*	*	*	*	*	*	*
190	*	*	*	*	*	*	*	*	*	*
180	*	*	*	*	*	*	*	*	*	*
170	*	*	*	*	*	*	*	*	*	*
160	*	*	*	*	*	*	*	*	*	*
150	*	*	*	*	*	*	*	*	*	*
140	*	*	*	*	*	*	*	*	*	*
130	*	*	*	*	*	*	*	*	*	*
120	*	*	*	*	*	*	*	*	*	*
110	*	*	*	*	*	*	*	*	*	*
100	*	*	*	*	*	*	*	*	*	*
90	*	*	*	*	*	*	*	*	*	*
80	*	*	*	*	*	*	*	*	*	*
70	*	*	*	*	*	*	*	*	*	*
60	*	*	*	*	*	*	*	*	*	*
50	*	*	*	*	*	*	*	*	*	*
40	*	*	*	*	*	*	*	*	*	*
30	*	*	*	*	*	*	*	*	*	*
20	*	*	*	*	*	*	*	*	*	*
10	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 2

ANNUAL FREQUENCY DISTRIBUTION OF STATE EQUALIZED VALUATION PER PUPIL

FREQUENCY	21650	22088	22838	24208	25660	27200	28832	30000	30000	30000
EACH * EQUALS	600									
30000								*	*	*
29400								*	*	*
28800							*	*	*	*
28200							*	*	*	*
27600							*	*	*	*
27000						*	*	*	*	*
26400						*	*	*	*	*
25800						*	*	*	*	*
25200					*	*	*	*	*	*
24600				*	*	*	*	*	*	*
24000				*	*	*	*	*	*	*
23400				*	*	*	*	*	*	*
22800			*	*	*	*	*	*	*	*
22200			*	*	*	*	*	*	*	*
21600	*	*	*	*	*	*	*	*	*	*
21000	*	*	*	*	*	*	*	*	*	*
20400	*	*	*	*	*	*	*	*	*	*
19800	*	*	*	*	*	*	*	*	*	*
19200	*	*	*	*	*	*	*	*	*	*
18600	*	*	*	*	*	*	*	*	*	*
18000	*	*	*	*	*	*	*	*	*	*
17400	*	*	*	*	*	*	*	*	*	*
16800	*	*	*	*	*	*	*	*	*	*
16200	*	*	*	*	*	*	*	*	*	*
15600	*	*	*	*	*	*	*	*	*	*
15000	*	*	*	*	*	*	*	*	*	*
14400	*	*	*	*	*	*	*	*	*	*
13800	*	*	*	*	*	*	*	*	*	*
13200	*	*	*	*	*	*	*	*	*	*
12600	*	*	*	*	*	*	*	*	*	*
12000	*	*	*	*	*	*	*	*	*	*
11400	*	*	*	*	*	*	*	*	*	*
10800	*	*	*	*	*	*	*	*	*	*
10200	*	*	*	*	*	*	*	*	*	*
9600	*	*	*	*	*	*	*	*	*	*
9000	*	*	*	*	*	*	*	*	*	*
8400	*	*	*	*	*	*	*	*	*	*
7800	*	*	*	*	*	*	*	*	*	*
7200	*	*	*	*	*	*	*	*	*	*
6600	*	*	*	*	*	*	*	*	*	*
6000	*	*	*	*	*	*	*	*	*	*
5400	*	*	*	*	*	*	*	*	*	*
4800	*	*	*	*	*	*	*	*	*	*
4200	*	*	*	*	*	*	*	*	*	*
3600	*	*	*	*	*	*	*	*	*	*
3000	*	*	*	*	*	*	*	*	*	*
2400	*	*	*	*	*	*	*	*	*	*
1800	*	*	*	*	*	*	*	*	*	*
1200	*	*	*	*	*	*	*	*	*	*
600	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 4

ANNUAL FREQUENCY DISTRIBUTION OF STATE AID PER PUPIL

FREQUENCY	514	603	646	671	698	726	755	785	817	850
EACH * EQUALS	17									
850										*
833										*
816										*
799										*
782								*	*	*
765								*	*	*
748							*	*	*	*
731							*	*	*	*
714						*	*	*	*	*
697					*	*	*	*	*	*
680					*	*	*	*	*	*
663				*	*	*	*	*	*	*
646			*	*	*	*	*	*	*	*
629			*	*	*	*	*	*	*	*
612			*	*	*	*	*	*	*	*
595		*	*	*	*	*	*	*	*	*
578		*	*	*	*	*	*	*	*	*
561		*	*	*	*	*	*	*	*	*
544		*	*	*	*	*	*	*	*	*
527		*	*	*	*	*	*	*	*	*
510	*	*	*	*	*	*	*	*	*	*
493	*	*	*	*	*	*	*	*	*	*
476	*	*	*	*	*	*	*	*	*	*
459	*	*	*	*	*	*	*	*	*	*
442	*	*	*	*	*	*	*	*	*	*
425	*	*	*	*	*	*	*	*	*	*
408	*	*	*	*	*	*	*	*	*	*
391	*	*	*	*	*	*	*	*	*	*
374	*	*	*	*	*	*	*	*	*	*
357	*	*	*	*	*	*	*	*	*	*
340	*	*	*	*	*	*	*	*	*	*
323	*	*	*	*	*	*	*	*	*	*
306	*	*	*	*	*	*	*	*	*	*
289	*	*	*	*	*	*	*	*	*	*
272	*	*	*	*	*	*	*	*	*	*
255	*	*	*	*	*	*	*	*	*	*
238	*	*	*	*	*	*	*	*	*	*
221	*	*	*	*	*	*	*	*	*	*
204	*	*	*	*	*	*	*	*	*	*
187	*	*	*	*	*	*	*	*	*	*
170	*	*	*	*	*	*	*	*	*	*
153	*	*	*	*	*	*	*	*	*	*
136	*	*	*	*	*	*	*	*	*	*
119	*	*	*	*	*	*	*	*	*	*
102	*	*	*	*	*	*	*	*	*	*
85	*	*	*	*	*	*	*	*	*	*
68	*	*	*	*	*	*	*	*	*	*
51	*	*	*	*	*	*	*	*	*	*
34	*	*	*	*	*	*	*	*	*	*
17	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM

7

- 31 -

ANNUAL FREQUENCY DISTRIBUTION OF AVERAGE SALARY OF NEW (0 YEARS EXP) TEACHERS

FREQUENCY	9820	10410	11034	11696	12398	13000	13000	13000	13000	13000
EACH * EQUALS	260									
13000						*	*	*	*	*
12740						*	*	*	*	*
12480						*	*	*	*	*
12220					*	*	*	*	*	*
11960					*	*	*	*	*	*
11700					*	*	*	*	*	*
11440				*	*	*	*	*	*	*
11180				*	*	*	*	*	*	*
10920			*	*	*	*	*	*	*	*
10660			*	*	*	*	*	*	*	*
10400		*	*	*	*	*	*	*	*	*
10140		*	*	*	*	*	*	*	*	*
9880		*	*	*	*	*	*	*	*	*
9620	*	*	*	*	*	*	*	*	*	*
9360	*	*	*	*	*	*	*	*	*	*
9100	*	*	*	*	*	*	*	*	*	*
8840	*	*	*	*	*	*	*	*	*	*
8580	*	*	*	*	*	*	*	*	*	*
8320	*	*	*	*	*	*	*	*	*	*
8060	*	*	*	*	*	*	*	*	*	*
7800	*	*	*	*	*	*	*	*	*	*
7540	*	*	*	*	*	*	*	*	*	*
7280	*	*	*	*	*	*	*	*	*	*
7020	*	*	*	*	*	*	*	*	*	*
6760	*	*	*	*	*	*	*	*	*	*
6500	*	*	*	*	*	*	*	*	*	*
6240	*	*	*	*	*	*	*	*	*	*
5980	*	*	*	*	*	*	*	*	*	*
5720	*	*	*	*	*	*	*	*	*	*
5460	*	*	*	*	*	*	*	*	*	*
5200	*	*	*	*	*	*	*	*	*	*
4940	*	*	*	*	*	*	*	*	*	*
4680	*	*	*	*	*	*	*	*	*	*
4420	*	*	*	*	*	*	*	*	*	*
4160	*	*	*	*	*	*	*	*	*	*
3900	*	*	*	*	*	*	*	*	*	*
3640	*	*	*	*	*	*	*	*	*	*
3380	*	*	*	*	*	*	*	*	*	*
3120	*	*	*	*	*	*	*	*	*	*
2860	*	*	*	*	*	*	*	*	*	*
2600	*	*	*	*	*	*	*	*	*	*
2340	*	*	*	*	*	*	*	*	*	*
2080	*	*	*	*	*	*	*	*	*	*
1820	*	*	*	*	*	*	*	*	*	*
1560	*	*	*	*	*	*	*	*	*	*
1300	*	*	*	*	*	*	*	*	*	*
1040	*	*	*	*	*	*	*	*	*	*
780	*	*	*	*	*	*	*	*	*	*
520	*	*	*	*	*	*	*	*	*	*
260	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM

8

- 32 -

ANNUAL FREQUENCY DISTRIBUTION OF AVERAGE SALARY OF EXPERIENCED TEACHERS

FREQUENCY	15899	16853	17865	18937	20073	21277	22000	22000	22000	22000
EACH * EQUALS	440									
22000							*	*	*	*
21560							*	*	*	*
21120						*	*	*	*	*
20680						*	*	*	*	*
20240						*	*	*	*	*
19800					*	*	*	*	*	*
19360					*	*	*	*	*	*
18920				*	*	*	*	*	*	*
18480				*	*	*	*	*	*	*
18040				*	*	*	*	*	*	*
17600			*	*	*	*	*	*	*	*
17160			*	*	*	*	*	*	*	*
16720		*	*	*	*	*	*	*	*	*
16280		*	*	*	*	*	*	*	*	*
15840	*	*	*	*	*	*	*	*	*	*
15400	*	*	*	*	*	*	*	*	*	*
14960	*	*	*	*	*	*	*	*	*	*
14520	*	*	*	*	*	*	*	*	*	*
14080	*	*	*	*	*	*	*	*	*	*
13640	*	*	*	*	*	*	*	*	*	*
13200	*	*	*	*	*	*	*	*	*	*
12760	*	*	*	*	*	*	*	*	*	*
12320	*	*	*	*	*	*	*	*	*	*
11880	*	*	*	*	*	*	*	*	*	*
11440	*	*	*	*	*	*	*	*	*	*
11000	*	*	*	*	*	*	*	*	*	*
10560	*	*	*	*	*	*	*	*	*	*
10120	*	*	*	*	*	*	*	*	*	*
9680	*	*	*	*	*	*	*	*	*	*
9240	*	*	*	*	*	*	*	*	*	*
8800	*	*	*	*	*	*	*	*	*	*
8360	*	*	*	*	*	*	*	*	*	*
7920	*	*	*	*	*	*	*	*	*	*
7480	*	*	*	*	*	*	*	*	*	*
7040	*	*	*	*	*	*	*	*	*	*
6600	*	*	*	*	*	*	*	*	*	*
6160	*	*	*	*	*	*	*	*	*	*
5720	*	*	*	*	*	*	*	*	*	*
5280	*	*	*	*	*	*	*	*	*	*
4840	*	*	*	*	*	*	*	*	*	*
4400	*	*	*	*	*	*	*	*	*	*
3960	*	*	*	*	*	*	*	*	*	*
3520	*	*	*	*	*	*	*	*	*	*
3080	*	*	*	*	*	*	*	*	*	*
2640	*	*	*	*	*	*	*	*	*	*
2200	*	*	*	*	*	*	*	*	*	*
1760	*	*	*	*	*	*	*	*	*	*
1320	*	*	*	*	*	*	*	*	*	*
880	*	*	*	*	*	*	*	*	*	*
440	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 9

ANNUAL FREQUENCY DISTRIBUTION OF ALL TEACHERS IN SCHOOLS

FREQUENCY	10297	10034	9768	9573	9405	9241	9102	9011	8966	8966

EACH * EQUALS	206									
10094	*									
9888	*	*								
9682	*	*	*							
9476	*	*	*	*						
9270	*	*	*	*	*					
9064	*	*	*	*	*	*	*			
8858	*	*	*	*	*	*	*	*	*	*
8652	*	*	*	*	*	*	*	*	*	*
8446	*	*	*	*	*	*	*	*	*	*
8240	*	*	*	*	*	*	*	*	*	*
8034	*	*	*	*	*	*	*	*	*	*
7828	*	*	*	*	*	*	*	*	*	*
7622	*	*	*	*	*	*	*	*	*	*
7416	*	*	*	*	*	*	*	*	*	*
7210	*	*	*	*	*	*	*	*	*	*
7004	*	*	*	*	*	*	*	*	*	*
6798	*	*	*	*	*	*	*	*	*	*
6592	*	*	*	*	*	*	*	*	*	*
6386	*	*	*	*	*	*	*	*	*	*
6180	*	*	*	*	*	*	*	*	*	*
5974	*	*	*	*	*	*	*	*	*	*
5768	*	*	*	*	*	*	*	*	*	*
5562	*	*	*	*	*	*	*	*	*	*
5356	*	*	*	*	*	*	*	*	*	*
5150	*	*	*	*	*	*	*	*	*	*
4944	*	*	*	*	*	*	*	*	*	*
4738	*	*	*	*	*	*	*	*	*	*
4532	*	*	*	*	*	*	*	*	*	*
4326	*	*	*	*	*	*	*	*	*	*
4120	*	*	*	*	*	*	*	*	*	*
3914	*	*	*	*	*	*	*	*	*	*
3708	*	*	*	*	*	*	*	*	*	*
3502	*	*	*	*	*	*	*	*	*	*
3296	*	*	*	*	*	*	*	*	*	*
3090	*	*	*	*	*	*	*	*	*	*
2884	*	*	*	*	*	*	*	*	*	*
2678	*	*	*	*	*	*	*	*	*	*
2472	*	*	*	*	*	*	*	*	*	*
2266	*	*	*	*	*	*	*	*	*	*
2060	*	*	*	*	*	*	*	*	*	*
1854	*	*	*	*	*	*	*	*	*	*
1648	*	*	*	*	*	*	*	*	*	*
1442	*	*	*	*	*	*	*	*	*	*
1236	*	*	*	*	*	*	*	*	*	*
1030	*	*	*	*	*	*	*	*	*	*
824	*	*	*	*	*	*	*	*	*	*
618	*	*	*	*	*	*	*	*	*	*
412	*	*	*	*	*	*	*	*	*	*
206	*	*	*	*	*	*	*	*	*	*

INTERVAL	73	74	75	76	77	78	79	80	81	8
YEARS	74	75	76	77	78	79	80	81	82	8

HISTOGRAM 15

ANNUAL FREQUENCY DISTRIBUTION OF SCHOOL BUDGET DEFICIT IN MILLIONS OF DOLLARS

FREQUENCY 25 19 12 2 0 0 0 0 0 0

EACH * EQUALS 1

24	*			
23	*			
22	*			
21	*			
20	*			
19	*	*		
18	*	*		
17	*	*		
16	*	*		
15	*	*		
14	*	*		
13	*	*		
12	*	*		
11	*	*	*	
10	*	*	*	
9	*	*	*	
8	*	*	*	
7	*	*	*	
6	*	*	*	
5	*	*	*	
4	*	*	*	
3	*	*	*	
2	*	*	*	
1	*	*	*	*

INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 17

ANNUAL FREQUENCY DISTRIBUTION OF THE FEDERAL AID REVENUE/PUPIL

FREQUENCY	129	160	163	171	179	188	198	208	218	229
EACH * EQUALS	5									
225										
220										
215									*	
210									*	
205								*	*	
200								*	*	
195							*	*	*	
190							*	*	*	
185						*	*	*	*	
180						*	*	*	*	
175					*	*	*	*	*	
170				*	*	*	*	*	*	
165				*	*	*	*	*	*	
160		*	*	*	*	*	*	*	*	
155		*	*	*	*	*	*	*	*	
150		*	*	*	*	*	*	*	*	
145		*	*	*	*	*	*	*	*	
140		*	*	*	*	*	*	*	*	
135		*	*	*	*	*	*	*	*	
130		*	*	*	*	*	*	*	*	
125	*	*	*	*	*	*	*	*	*	
120	*	*	*	*	*	*	*	*	*	
115	*	*	*	*	*	*	*	*	*	
110	*	*	*	*	*	*	*	*	*	
105	*	*	*	*	*	*	*	*	*	
100	*	*	*	*	*	*	*	*	*	
95	*	*	*	*	*	*	*	*	*	
90	*	*	*	*	*	*	*	*	*	
85	*	*	*	*	*	*	*	*	*	
80	*	*	*	*	*	*	*	*	*	
75	*	*	*	*	*	*	*	*	*	
70	*	*	*	*	*	*	*	*	*	
65	*	*	*	*	*	*	*	*	*	
60	*	*	*	*	*	*	*	*	*	
55	*	*	*	*	*	*	*	*	*	
50	*	*	*	*	*	*	*	*	*	
45	*	*	*	*	*	*	*	*	*	
40	*	*	*	*	*	*	*	*	*	
35	*	*	*	*	*	*	*	*	*	
30	*	*	*	*	*	*	*	*	*	
25	*	*	*	*	*	*	*	*	*	
20	*	*	*	*	*	*	*	*	*	
15	*	*	*	*	*	*	*	*	*	
10	*	*	*	*	*	*	*	*	*	
5	*	*	*	*	*	*	*	*	*	
INTERVAL	73	74	75	76	77	78	79	80	81	8
YEARS	74	75	76	77	78	79	80	81	82	8

HISTOGRAM 15

ANNUAL FREQUENCY DISTRIBUTION OF THE TOTAL SCHOL EXPENSES FOR TEACHERS SALARY,
PRINGE BENEFITS, ADMINISTRATIVE AND OTHER EXPENSES (IN MILLIONS OF DOLLARS)

FREQUENCY	336	349	360	374	389	406	413	408	406	406
EACH * EQUALS	9									
405						*	*	*	*	*
396						*	*	*	*	*
387					*	*	*	*	*	*
378					*	*	*	*	*	*
369				*	*	*	*	*	*	*
360			*	*	*	*	*	*	*	*
351			*	*	*	*	*	*	*	*
342		*	*	*	*	*	*	*	*	*
333	*	*	*	*	*	*	*	*	*	*
324	*	*	*	*	*	*	*	*	*	*
315	*	*	*	*	*	*	*	*	*	*
306	*	*	*	*	*	*	*	*	*	*
297	*	*	*	*	*	*	*	*	*	*
288	*	*	*	*	*	*	*	*	*	*
279	*	*	*	*	*	*	*	*	*	*
270	*	*	*	*	*	*	*	*	*	*
261	*	*	*	*	*	*	*	*	*	*
252	*	*	*	*	*	*	*	*	*	*
243	*	*	*	*	*	*	*	*	*	*
234	*	*	*	*	*	*	*	*	*	*
225	*	*	*	*	*	*	*	*	*	*
216	*	*	*	*	*	*	*	*	*	*
207	*	*	*	*	*	*	*	*	*	*
198	*	*	*	*	*	*	*	*	*	*
189	*	*	*	*	*	*	*	*	*	*
180	*	*	*	*	*	*	*	*	*	*
171	*	*	*	*	*	*	*	*	*	*
162	*	*	*	*	*	*	*	*	*	*
153	*	*	*	*	*	*	*	*	*	*
144	*	*	*	*	*	*	*	*	*	*
135	*	*	*	*	*	*	*	*	*	*
126	*	*	*	*	*	*	*	*	*	*
117	*	*	*	*	*	*	*	*	*	*
108	*	*	*	*	*	*	*	*	*	*
99	*	*	*	*	*	*	*	*	*	*
90	*	*	*	*	*	*	*	*	*	*
81	*	*	*	*	*	*	*	*	*	*
72	*	*	*	*	*	*	*	*	*	*
63	*	*	*	*	*	*	*	*	*	*
54	*	*	*	*	*	*	*	*	*	*
45	*	*	*	*	*	*	*	*	*	*
36	*	*	*	*	*	*	*	*	*	*
27	*	*	*	*	*	*	*	*	*	*
18	*	*	*	*	*	*	*	*	*	*
9	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 19

ANNUAL FREQUENCY DISTRIBUTION OF LOCAL TAX REVENUE PER PUPIL

FREQUENCY	520	596	639	702	770	816	865	900	900	900
EACH * EQUALS	18									
900								*	*	*
882								*	*	*
864							*	*	*	*
846							*	*	*	*
828							*	*	*	*
810						*	*	*	*	*
792						*	*	*	*	*
774					*	*	*	*	*	*
756					*	*	*	*	*	*
738					*	*	*	*	*	*
720					*	*	*	*	*	*
702				*	*	*	*	*	*	*
684				*	*	*	*	*	*	*
666				*	*	*	*	*	*	*
648				*	*	*	*	*	*	*
630			*	*	*	*	*	*	*	*
612			*	*	*	*	*	*	*	*
594		*	*	*	*	*	*	*	*	*
576		*	*	*	*	*	*	*	*	*
558		*	*	*	*	*	*	*	*	*
540		*	*	*	*	*	*	*	*	*
522		*	*	*	*	*	*	*	*	*
504	*	*	*	*	*	*	*	*	*	*
486	*	*	*	*	*	*	*	*	*	*
468	*	*	*	*	*	*	*	*	*	*
450	*	*	*	*	*	*	*	*	*	*
432	*	*	*	*	*	*	*	*	*	*
414	*	*	*	*	*	*	*	*	*	*
396	*	*	*	*	*	*	*	*	*	*
378	*	*	*	*	*	*	*	*	*	*
360	*	*	*	*	*	*	*	*	*	*
342	*	*	*	*	*	*	*	*	*	*
324	*	*	*	*	*	*	*	*	*	*
306	*	*	*	*	*	*	*	*	*	*
288	*	*	*	*	*	*	*	*	*	*
270	*	*	*	*	*	*	*	*	*	*
252	*	*	*	*	*	*	*	*	*	*
234	*	*	*	*	*	*	*	*	*	*
216	*	*	*	*	*	*	*	*	*	*
198	*	*	*	*	*	*	*	*	*	*
180	*	*	*	*	*	*	*	*	*	*
162	*	*	*	*	*	*	*	*	*	*
144	*	*	*	*	*	*	*	*	*	*
126	*	*	*	*	*	*	*	*	*	*
108	*	*	*	*	*	*	*	*	*	*
90	*	*	*	*	*	*	*	*	*	*
72	*	*	*	*	*	*	*	*	*	*
54	*	*	*	*	*	*	*	*	*	*
36	*	*	*	*	*	*	*	*	*	*
18	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM

24

ANNUAL FREQUENCY DISTRIBUTION OF NEWLY ADMITTED STUDENTS OF THE COLLEGE

FREQUENCY	1712	1553	1396	1236	1077	920	760	601	448	400
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EACH * EQUALS 35

1680	*									
1645	*									
1610	*									
1575	*									
1540	*	*								
1505	*	*								
1470	*	*								
1435	*	*								
1400	*	*								
1365	*	*	*							
1330	*	*	*							
1295	*	*	*							
1260	*	*	*							
1225	*	*	*	*						
1190	*	*	*	*						
1155	*	*	*	*						
1120	*	*	*	*						
1085	*	*	*	*						
1050	*	*	*	*	*					
1015	*	*	*	*	*	*				
980	*	*	*	*	*	*				
945	*	*	*	*	*	*				
910	*	*	*	*	*	*	*			
875	*	*	*	*	*	*	*			
840	*	*	*	*	*	*	*			
805	*	*	*	*	*	*	*			
770	*	*	*	*	*	*	*			
735	*	*	*	*	*	*	*	*		
700	*	*	*	*	*	*	*	*		
665	*	*	*	*	*	*	*	*		
630	*	*	*	*	*	*	*	*		
595	*	*	*	*	*	*	*	*	*	
560	*	*	*	*	*	*	*	*	*	
525	*	*	*	*	*	*	*	*	*	
490	*	*	*	*	*	*	*	*	*	
455	*	*	*	*	*	*	*	*	*	
420	*	*	*	*	*	*	*	*	*	*
385	*	*	*	*	*	*	*	*	*	*
350	*	*	*	*	*	*	*	*	*	*
315	*	*	*	*	*	*	*	*	*	*
280	*	*	*	*	*	*	*	*	*	*
245	*	*	*	*	*	*	*	*	*	*
210	*	*	*	*	*	*	*	*	*	*
175	*	*	*	*	*	*	*	*	*	*
140	*	*	*	*	*	*	*	*	*	*
105	*	*	*	*	*	*	*	*	*	*
70	*	*	*	*	*	*	*	*	*	*
35	*	*	*	*	*	*	*	*	*	*

INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 30

ANNUAL FREQUENCY DISTRIBUTION OF ALL GRADUATES OF THE COLLEGE OF EDUCATION

FREQUENCY	1091	1006	923	843	764	685	606	526	446	366
EACH * EQUALS	22									
1078	*									
1056	*									
1034	*									
1012	*									
990	*	*								
968	*	*								
946	*	*								
924	*	*								
902	*	*	*							
880	*	*	*							
858	*	*	*							
836	*	*	*	*						
814	*	*	*	*						
792	*	*	*	*						
770	*	*	*	*						
748	*	*	*	*	*					
726	*	*	*	*	*					
704	*	*	*	*	*					
682	*	*	*	*	*	*				
660	*	*	*	*	*	*				
638	*	*	*	*	*	*				
616	*	*	*	*	*	*				
594	*	*	*	*	*	*	*			
572	*	*	*	*	*	*	*			
550	*	*	*	*	*	*	*			
528	*	*	*	*	*	*	*	*		
506	*	*	*	*	*	*	*	*		
484	*	*	*	*	*	*	*	*	*	
462	*	*	*	*	*	*	*	*	*	
440	*	*	*	*	*	*	*	*	*	*
418	*	*	*	*	*	*	*	*	*	*
396	*	*	*	*	*	*	*	*	*	*
374	*	*	*	*	*	*	*	*	*	*
352	*	*	*	*	*	*	*	*	*	*
330	*	*	*	*	*	*	*	*	*	*
308	*	*	*	*	*	*	*	*	*	*
286	*	*	*	*	*	*	*	*	*	*
264	*	*	*	*	*	*	*	*	*	*
242	*	*	*	*	*	*	*	*	*	*
220	*	*	*	*	*	*	*	*	*	*
198	*	*	*	*	*	*	*	*	*	*
176	*	*	*	*	*	*	*	*	*	*
154	*	*	*	*	*	*	*	*	*	*
132	*	*	*	*	*	*	*	*	*	*
110	*	*	*	*	*	*	*	*	*	*
88	*	*	*	*	*	*	*	*	*	*
66	*	*	*	*	*	*	*	*	*	*
44	*	*	*	*	*	*	*	*	*	*
22	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 31

ANNUAL-FREQUENCY DISTRIBUTION OF THE WSU FRESH GRADUATES SEEKING TEACHING JOB

FREQUENCY	568	525	480	435	395	358	312	270	233	190
EACH * EQUALS	12									
564	*									
552	*									
540	*									
528	*									
516	*	*								
504	*	*								
492	*	*								
480	*	*	*							
468	*	*	*							
456	*	*	*							
444	*	*	*							
432	*	*	*	*						
420	*	*	*	*						
408	*	*	*	*						
396	*	*	*	*						
384	*	*	*	*	*					
372	*	*	*	*	*					
360	*	*	*	*	*					
348	*	*	*	*	*	*				
336	*	*	*	*	*	*				
324	*	*	*	*	*	*				
312	*	*	*	*	*	*	*			
300	*	*	*	*	*	*	*			
288	*	*	*	*	*	*	*			
276	*	*	*	*	*	*	*			
264	*	*	*	*	*	*	*	*		
252	*	*	*	*	*	*	*	*		
240	*	*	*	*	*	*	*	*	*	
228	*	*	*	*	*	*	*	*	*	*
216	*	*	*	*	*	*	*	*	*	*
204	*	*	*	*	*	*	*	*	*	*
192	*	*	*	*	*	*	*	*	*	*
180	*	*	*	*	*	*	*	*	*	*
168	*	*	*	*	*	*	*	*	*	*
156	*	*	*	*	*	*	*	*	*	*
144	*	*	*	*	*	*	*	*	*	*
132	*	*	*	*	*	*	*	*	*	*
120	*	*	*	*	*	*	*	*	*	*
108	*	*	*	*	*	*	*	*	*	*
96	*	*	*	*	*	*	*	*	*	*
84	*	*	*	*	*	*	*	*	*	*
72	*	*	*	*	*	*	*	*	*	*
60	*	*	*	*	*	*	*	*	*	*
48	*	*	*	*	*	*	*	*	*	*
36	*	*	*	*	*	*	*	*	*	*
24	*	*	*	*	*	*	*	*	*	*
12	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

HISTOGRAM 34

ANNUAL FREQUENCY DISTRIBUTION OF THE NUMBER OF WSU EXPERIENCED TEACHERS WAITING TO BE EMPLOYED

FREQUENCY	1734	2041	2332	2548	2693	2791	2811	2760	2656	2477
EACH * EQUALS	57									
2793							*			
2736						*	*	*		
2679					*	*	*	*		
2622					*	*	*	*	*	
2565					*	*	*	*	*	
2508				*	*	*	*	*	*	
2451				*	*	*	*	*	*	*
2394				*	*	*	*	*	*	*
2337				*	*	*	*	*	*	*
2280			*	*	*	*	*	*	*	*
2223			*	*	*	*	*	*	*	*
2166			*	*	*	*	*	*	*	*
2109			*	*	*	*	*	*	*	*
2052			*	*	*	*	*	*	*	*
1995		*	*	*	*	*	*	*	*	*
1938		*	*	*	*	*	*	*	*	*
1881		*	*	*	*	*	*	*	*	*
1824		*	*	*	*	*	*	*	*	*
1767		*	*	*	*	*	*	*	*	*
1710	*	*	*	*	*	*	*	*	*	*
1653	*	*	*	*	*	*	*	*	*	*
1596	*	*	*	*	*	*	*	*	*	*
1539	*	*	*	*	*	*	*	*	*	*
1482	*	*	*	*	*	*	*	*	*	*
1425	*	*	*	*	*	*	*	*	*	*
1368	*	*	*	*	*	*	*	*	*	*
1311	*	*	*	*	*	*	*	*	*	*
1254	*	*	*	*	*	*	*	*	*	*
1197	*	*	*	*	*	*	*	*	*	*
1140	*	*	*	*	*	*	*	*	*	*
1083	*	*	*	*	*	*	*	*	*	*
1026	*	*	*	*	*	*	*	*	*	*
969	*	*	*	*	*	*	*	*	*	*
912	*	*	*	*	*	*	*	*	*	*
855	*	*	*	*	*	*	*	*	*	*
798	*	*	*	*	*	*	*	*	*	*
741	*	*	*	*	*	*	*	*	*	*
684	*	*	*	*	*	*	*	*	*	*
627	*	*	*	*	*	*	*	*	*	*
570	*	*	*	*	*	*	*	*	*	*
513	*	*	*	*	*	*	*	*	*	*
456	*	*	*	*	*	*	*	*	*	*
399	*	*	*	*	*	*	*	*	*	*
342	*	*	*	*	*	*	*	*	*	*
285	*	*	*	*	*	*	*	*	*	*
228	*	*	*	*	*	*	*	*	*	*
171	*	*	*	*	*	*	*	*	*	*
114	*	*	*	*	*	*	*	*	*	*
57	*	*	*	*	*	*	*	*	*	*
INTERVAL	73	74	75	76	77	78	79	80	81	82
YEARS	74	75	76	77	78	79	80	81	82	83

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